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(54) Title: IN-LINE COMPOUNDING AND EXTRUSION SYSTEM

(57) Abstract

The present invention is a continuous in-line compounding and extrusion system that does not require pre-dried wood flour or pelletized feed stock of cellulosic/polymer composite materials in order to produce net shapes from cellulosic/polymer composite materials. A preferred embodiment of the present invention utilizes automated loss-in-weight feeders to dispense wood flour and all of the other cellulosic/polymer composite materials into a compounder. The compounder blends the cellulosic/polymer composite materials into a composite melt. The composite melt is continuously devolitalized as it travels through the compounder, a transition chute, and a finish extruder. The composite melt is then forced through a profile die which is fitted to the finish extruder in order to achieve a net shape.

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# IN-LINE COMPOUNDING AND EXTRUSION SYSTEM

## BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to a continuous in-line compounding and extrusion system, and more particularly to, a continuous in-line compounding and extrusion system that produces net shapes. The present invention is useful for several different formulations and material composites including, but not limited to, poly-vinyl chloride (PVC) formulations, polyethylene (HDPE) formulations, and cellulosic/polymer composites. The present invention will be described primarily with reference to cellulosic/polymer composites, but it is also intended for use with other material composites and formulations.

Cellulosic/polymer composites are used as replacements for all-natural wood, particle board, wafer board, and other similar materials. In recent years, a tremendous demand has developed for cellulosic/polymer composites that exhibit the look and feel of natural woods. Unfortunately, the supply of natural woods for construction and other purposes is dwindling. Consequently, many are concerned about conserving the world's forests, and the cost of natural woods has risen.

The demand for cellulosic/polymer composites has also increased for other reasons. As compared to natural woods, cellulosic/polymer composites offer superior resistance to wear and tear. In particular, cellulosic/polymer composites have enhanced resistance to moisture. In fact, it is well known that the retention of moisture is a primary cause of the warping, splintering, and discoloration of natural woods. Moreover, cellulosic/polymer composites may be sawed, sanded, shaped, turned, fastened, and finished in the same manner as natural woods. Therefore, cellulosic/polymer composites are commonly used for

applications such as interior and exterior decorative house moldings, picture frames, furniture, porch decks, window moldings, window components, door components, and roofing structures.

Traditionally, two types of processes have been employed to manufacture cellulosic/polymer composites. The first type of process manufactures the cellulosic/polymer composite materials into pelletized feed stock that is later, at another site, fed into a single or twin-screw extruder. The output of the extruder is then sent through a profile die to obtain a net shape. However, this type of manufacturing process has drawbacks because it requires an independent mixing and storage system to compound, pelletize, cool, package, and store feed stock of the cellulosic/polymer composite materials.

The second type of manufacturing process eliminates the need to pelletize, cool, package, and store feed stock of the cellulosic/polymer composite materials. Instead, the second type of manufacturing process blends the polymer materials into a homogeneous mixture. The homogeneous mixture is delivered to a site where it is then combined with pre-dried wood flour. The resulting composition is fed through a twin-screw extruder which converts the composition into a fused melt. The fused melt is then pumped through a profile die to achieve a net shape.

Conventional use of a twin-screw extruder, however, is not an efficient means to maintain a relatively dry mixture. Moreover, when employing the second type of manufacturing process, precise guidelines must be adhered to in order to achieve the superior qualities of cellulosic/polymer composites. Most importantly, the wood flour that constitutes the cellulosic material must be dried before it is extruded. As is well known in the art, failure

to dry the wood flour before it is extruded will commonly result in a fragile composite that is susceptible to cracking, blistering, and deteriorating appearance.

Once the wood flour is dried to the appropriate moisture content level for the second type of manufacturing process, care must also be taken to prevent the wood flour from reabsorbing additional moisture before it is extruded. Early attempts at manufacturing cellulosic/polymer composites failed because the wood flour was stored in humid manufacturing environments before it was extruded. Compounding systems for the second type of manufacturing process have since been employed to prevent the wood flour from absorbing undesired moisture. One such system utilizes a large dryer to pre-dry the wood flour and to maintain a dry storage environment for the wood flour.

Cost is an inherent drawback to using a large dryer to pre-dry the wood flour or to maintain a dry storage environment for the wood flour. For example, a drying/blending system for a large scale production facility can cost several million dollars. In addition, this type of compounding system requires bulky storage containers to hold the cellulosic/polymer composite materials, an elaborate piping and control system to transfer the cellulosic/polymer composite materials to various holding stations, and an independent mixing mechanism to combine the cellulosic/polymer composite materials. Consequently, such a compounding system is costly, susceptible to wear and tear, and time-consuming.

On the other hand, a compounding system which utilizes pre-dried wood flour that has been purchased from a remote commercial compounder also has shortcomings. The extra cost of dealing with a remote commercial compounder is not desirable, and the wood flour may have to be redried once it arrives at the extrusion facility prior to passing it through the extruder. This approach also has inherent drawbacks such as ordering, shipping, and material

may be manually performed, it is well known in the art that loss-in-weight feeders may be automated to continuously dispense the desired ratio of cellulosic/polymer composite materials to the compounder **20**.

The compounder **20** is utilized to blend the cellulosic/polymer composite materials into a composite melt. A CP Compact Compounder (CP1000) by the Farrel Corporation may be used for this purpose. Figure 2 includes a diagram of a compounder **20**. As shown in Figure 2, a compounder **20** may include a touch view control screen **80**, an electric motor actuator **81**, visco seals **82**, a vent **83**, a melt temp thermocouple **84**, a teflon-impregnated, electrically heated orifice **85**, an electrically heated, segmented chamber barrel **86**, a rotor with three-piece quick disconnect couplings **87**, packing glands **88**, grease packed bearings **89**, and a unidrive gear reducer **90**.

The compounder **20** continuously devolitalizes the composite melt. As the compounder **20** devolitalizes the composite melt, the composite melt travels through a second aperture of the compounder **20**. A transition chute **30** is coupled to the compounder **20** for transferring the composite melt to a finish extruder **40**. The transition chute **30** has a first end which receives the composite melt from the second aperture of the compounder **20**. The composite melt continues to devolitalize as it travels through the transition chute **30**. The composite melt then travels through a second end of the transition chute **30**.

The compounder **20** and the transition chute **30** may be independent units which are coupled together. However, a CP Compact Compounder (CP1000) by the Farrel Corporation is equipped with a compounder **20** and a transition chute **30** which may perform the aforementioned functions. Regardless of the method of manufacture, the finish extruder **40**

may be coupled to the transition chute 30 so that the finish extruder 40 receives the composite melt from the second end of the transition chute 30.

The composite melt continues to devolitalize as it travels through and is extruded by the finish extruder 40. The finish extruder 40 may be a single-screw extruder or a twin-screw extruder. For example, a preferred embodiment of the present invention may use a twin-screw extruder (CM-80-Hp) by Cincinnati Milacron. At least one shaping device 50 is fitted to the finish extruder 40. Each shaping device 50 has at least one orifice through which the composite melt is forced in order to form the composite melt into a net shape. Profile dies and composite molders are examples of shaping devices 50 that are commonly used to perform this function. It is further known in the art that a plurality of such shaping devices 50 may be fitted to the finish extruder 40 in order to achieve a desired net shape.

In addition to the process described above, additional measures may be taken to achieve greater devolitalization of the composite melt. For instance, each feeder that dispenses cellulosic materials into the compounder 20 may be heated in order to dry the cellulosic materials as the cellulosic materials are dispensed into the compounder 20. In addition, the composite melt may be subjected to one or more vacuums while it travels through the compounder 20. In order to achieve this function, a compounder vacuum 60 is connected to a vent 83 of compounder 20. Similarly, the composite melt may be subjected to one or more vacuums while it is pumped through the finish extruder 40. This feature may be achieved, for example, by connecting an extruder vacuum 70 to a vent port 100 of finish extruder 40.

None of the measures described above to achieve greater devolitalization of the composite melt is exclusive of the others. If a cellulosic/polymer composite has a low

cellulosic content, additional measures may not be required to devolitalize the composite melt. However, if the cellulosic/polymer composite has a high cellulosic content, several, if not all, of the additional measures may be employed in order to achieve adequate devolitalization of the composite melt.

The preferred embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the invention. The preferred embodiments were chosen and described in order to explain the principles of the present invention so that others skilled in the art may practice the invention. Having shown and described preferred embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention. Many of those variations and modifications will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

WHAT IS CLAIMED IS:

1. A process for producing net shapes from cellulosic\polymer composite materials, said process comprising:

providing cellulosic\polymer composite materials;

dispensing a desired ratio of cellulosic\polymer composite materials into a compounder;

utilizing the compounder to blend the cellulosic/polymer composite materials into a composite melt;

devolitalizing the composite melt while the composite melt travels through the compounder, a transition chute, and a finish extruder; and

forcing the composite melt through at least one shaping device in order to form a net shape.

2. The process of claim 1 further comprising the step of drying the cellulosic materials as the cellulosic materials are dispensed into the compounder.

3. The process of claim 2 further comprising the step of subjecting the composite melt to a vacuum while it travels through the compounder.

4. The process of claim 2 further comprising the step of subjecting the composite melt to a vacuum while it travels through the finish extruder.

5. The process of claim 2 further comprising the steps of:

subjecting the composite melt to a vacuum while it travels through the compounder; and

subjecting the composite melt to a vacuum while it travels through the finish extruder.

6. The process of claim 1 further comprising the step of subjecting the composite melt to a vacuum while it travels through the compounder.

7. The process of claim 6 further comprising the step of subjecting the composite melt to a vacuum while it travels through the finish extruder.

8. The process of claim 1 further comprising the step of subjecting the composite melt to a vacuum while it travels through the finish extruder.

9. The process of claim 1 wherein a desired ratio of cellulosic/polymer composite materials is continuously dispensed into the compounder.

10. An in-line compounding and extrusion system for producing net shapes from cellulosic/polymer composite materials, said in-line compounding and extrusion system comprising:

cellulosic/polymer composite materials;

a compounder for blending the cellulosic/polymer composite materials into a composite melt, said compounder having a first aperture for receiving the cellulosic/polymer composite materials, said compounder also having a second aperture through which the composite melt travels;

a transition chute coupled to the compounder for transferring the composite melt, said transition chute having a first end to receive the composite melt from the second aperture of the compounder, said transition chute also having a second end through which the composite melt travels;

a finish extruder to extrude the composite melt after receiving the composite melt from the second end of the transition chute; and

at least one shaping device fitted to the finish extruder, each shaping device having at least one orifice through which the composite melt is forced in order to form a net shape.

11. The in-line compounding and extrusion system of claim 10 further comprising at least one material storage container for storing the cellulosic/polymer composite materials, said at least one material storage container having at least one feeder to dispense its contents.

12. The in-line compounding and extrusion system of claim 11 wherein the first aperture of the compounder receives the cellulosic/polymer composite materials from the at least one feeder.

13. The in-line compounding and extrusion system of claim 11 wherein:

the cellulosic/polymer composite materials include cellulosic materials; and

the at least one feeder that dispenses the cellulosic materials is heated in order to dry the cellulosic materials.

14. The in-line compounding and extrusion system of claim 13 wherein:

the compounder has a vent; and

a compounder vacuum is connected to the vent such that the composite melt is placed in a vacuum while it travels through the compounder.

15. The in-line compounding and extrusion system of claim 13 wherein:

the finish extruder has a vent port; and

an extruder vacuum is connected to the vent port such that the composite melt is placed in a vacuum while it travels through the finish extruder.

16. The in-line compounding and extrusion system of claim 15 wherein:

the compounder has a vent; and

a compounder vacuum is connected to the vent such that the composite melt is placed in a vacuum while it travels through the compounder.

17. The in-line compounding and extrusion system of claim 10 wherein:

the compounder has a vent; and

a compounder vacuum is connected to the vent such that the composite melt is placed in a vacuum while it travels through the compounder.

18. The in-line compounding and extrusion system of claim 17 wherein:

the finish extruder has a vent port; and

an extruder vacuum is connected to the vent port such that the composite melt is placed in a vacuum while it travels through the finish extruder.

19. The in-line compounding and extrusion system of claim 10 wherein:

the finish extruder has a vent port; and

an extruder vacuum is connected to the vent port such that the composite melt is placed in a vacuum while it travels through the finish extruder.

20. The in-line compounding and extrusion system of claim 10 wherein the finish extruder is a single-screw extruder.

21. The in-line compounding and extrusion system of claim 10 wherein the finish extruder is a twin-screw extruder.

22. The in-line compounding and extrusion system of claim 10 wherein at least one of the at least one shaping device is a profile die.

23. The in-line compounding and extrusion system of claim 22 wherein the profile die has more than one orifice.

24. The in-line compounding and extrusion system of claim 10 wherein at least one of the at least one shaping device is a continuous molder.

25. The in-line compounding and extrusion system of claim 10 further comprising at least one loss-in-weight feeder for storing the cellulosic/polymer composite materials, said at least one loss-in-weight feeder having at least one feeder to dispense its contents.

26. The in-line compounding and extrusion system of claim 25 wherein the at least one loss-in-weight feeder is automated to dispense a desired ratio of cellulosic/polymer composite materials.

27. A process for producing net shapes from a material that may be adapted to be formed into a net shape, said process comprising:

providing a material that may be adapted to be formed into a net shape;

dispensing the material into a compounder;

utilizing the compounder to blend the material into a composite melt;

devolitalizing the composite melt while the composite melt travels through the compounder, a transition chute, and a finish extruder; and

forcing the composite melt through at least one shaping device in order to form a net shape.

28. The process of claim 27 wherein the material is a formulation that incorporates polyethylene.

29. The process of claim 27 wherein the material is a formulation that incorporates poly-vinyl chloride.

30. An in-line compounding and extrusion system for producing net shapes from a material that may be adapted to be formed into a net shape, said in-line compounding and extrusion system comprising:

a material that may be adapted to be formed into a net shape;

a compounder for blending the material into a composite melt, said compounder having a first aperture for receiving the material, said compounder also having a second aperture through which the composite melt travels;

a transition chute coupled to the compounder for transferring the composite melt, said transition chute having a first end to receive the composite melt from the second aperture of the compounder, said transition chute also having a second end through which the composite melt travels;

a finish extruder to extrude the composite melt after receiving the composite melt from the second end of the transition chute; and

at least one shaping device fitted to the finish extruder, each shaping device having at least one orifice through which the composite melt is forced in order to form a net shape.

31. The in-line compounding and extrusion system of claim 30 wherein the material is a formulation that incorporates polyethylene.

32. The in-line compounding and extrusion system of claim 30 wherein the material is a formulation that incorporates poly-vinyl chloride.

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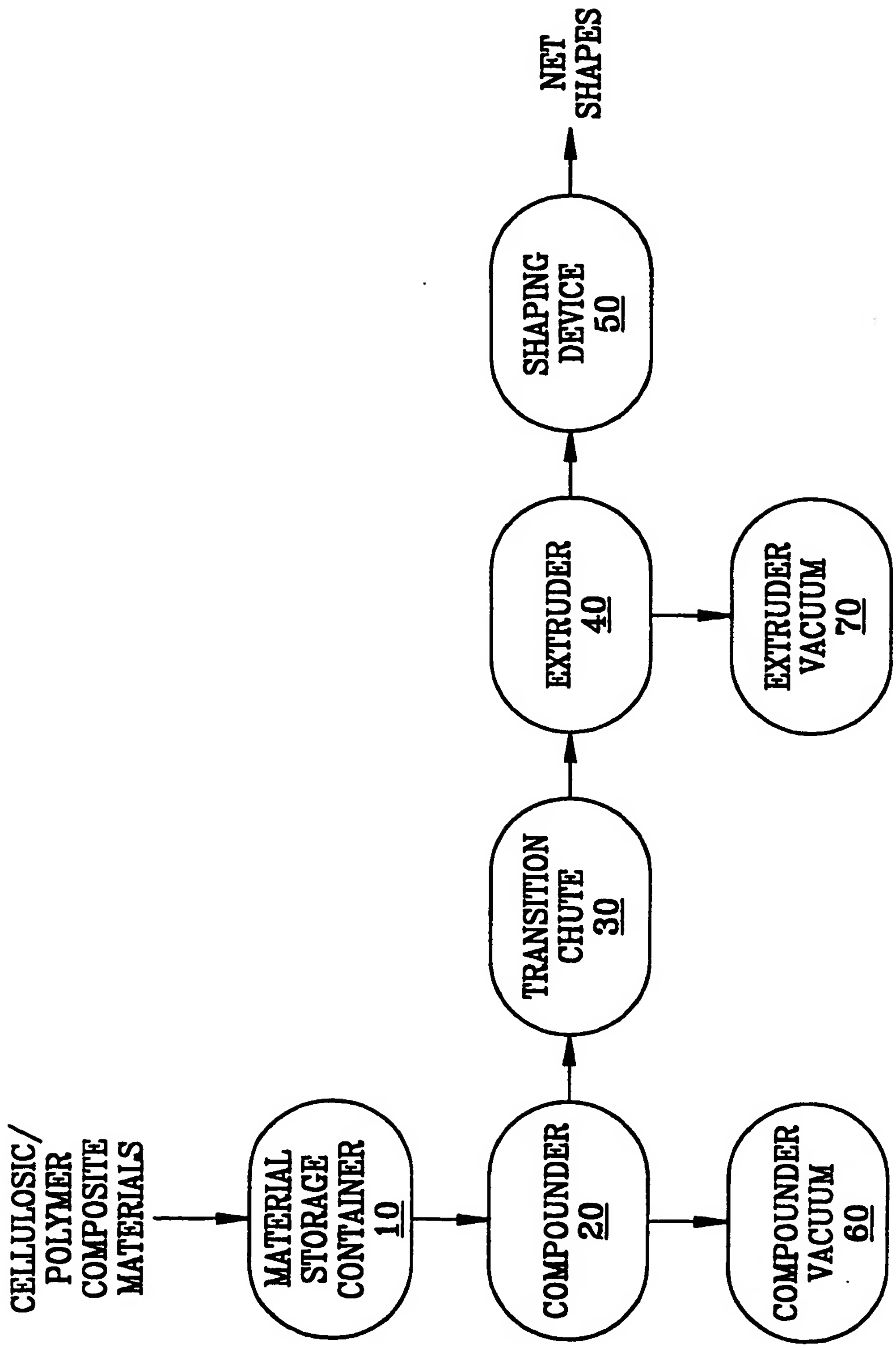
CELLULOSIC/ POLYMER COMPOSITE MATERIALS
MATERIAL STORAGE CONTAINER 10
COMPOUNDER 20
COMPOUNDER VACUUM 60
TRANSITION CHUTE 30
EXTRUDER 40
EXTRUDER VACUUM 70
SHAPING DEVICE 50
NET SHAPES

FIG—1

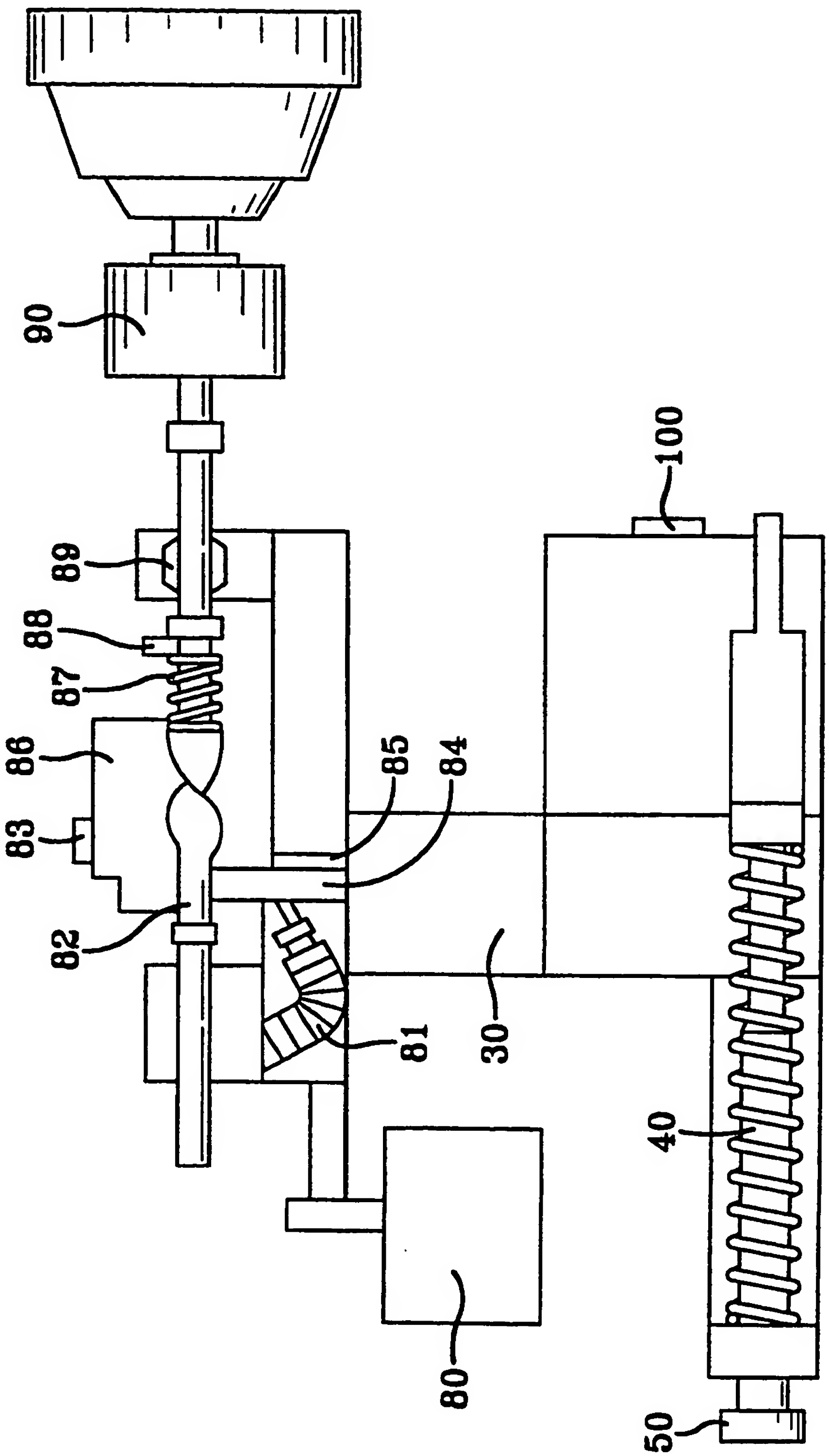


FIG-2

| INTERNATIONAL SEARCH REPORT | International application No. PCT/US98/18916 |
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**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :B29B 7/40, 7/84; B29C 47/76, 47/92
US CL : 264/101, 102, 211.12
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 264/101, 102, 211.12

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 5,518,677 A (DEANER et al) 21 May 1996 (21-05-96), column 5, lines 17-61, column 3, lines 56, 62, Figure 1, column 6, lines 32+, column 7, lines 14-15, 20-21, column 9, lines 37-45, column 10, lines 43-44. | 1-32 |
| Y | US 5,589,203 A (SATO) 31 December 1996 (31-12-96), Figure 2. | 1-32 |
| Y | US 4,902,455 A (WOBBE) 20 February 1990 (20-02-90), Figures 1-7. | 1-32 |
| Y | US 1,156,096 A (PRICE) 12 October 1915 (12-10-15), Figure 3. | 1-32 |
| Y | US 5,437,826 A (MARTINELLO et al) 01 August 1995 (01-08-95), Figures 1-4. | 1-32 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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